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6 April 1984

# USSR Report

PHYSICS AND MATHEMATICS



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6 April 1984

# USSR REPORT

## PHYSICS AND MATHEMATICS

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## EXCITATION OF SOUND BY LIGHT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 2, Jan 84  
(manuscript received 21 Feb 83) pp 309-311

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[Abstract] Sound producing interaction of light and a binary gas mixture is analyzed, assuming that only one component of the mixture absorbs light and its particles have a two-level structure. The other component plays the role of a buffer and its particles are assumed to be structureless. The wave equation describing acoustic vibrations in terms of the unbalance pressure differential is derived from the equations of gas dynamics, after they have been linearized. The solution is simplest in the limiting case where excited and nonexcited particles of the light-absorbing component have almost equal cross sections for collision with particles of the buffer component, these cross sections being nearly independent of the kind of buffer gas, and particles of both components having equal masses. The solution is obtained in terms of Chapman-Cowling  $\Omega$ -integrals. As an example the author considers a gas mixture inside a cylindrical resonator cavity and incident light with an intensity which oscillates in time at an acoustic frequency while remaining uniformly distributed over the cavity cross section. The saturation factor, proportional to the light intensity, is assumed to oscillate at constant amplitude in time and to decrease exponentially along the light path. The time-average density of acoustic energy is calculated for the case of a laser beam with Gaussian transverse light intensity distribution impinging on a rigid ideally smooth wall of such a cylindrical gas container. In accordance with the law of energy conservation, emission of sound from the container into the ambient medium causes the gas inside to cool down. The results confirm that light can excite sound also in the special case of a gas without buffer. The results apply to generation of sound through light-induced drift converting random motion of gas particles to regular motion and from heat, as in the case of a "radiation-collision" antenna. The author thanks S. G. Rautian and A. M. Shalagin for discussion and valuable comments. Article was presented by Academician Yu. Ye. Nesterikhin on 11 February 1983. References 9: 8 Russian, 1 Western.  
[25-2415]

USE OF PELTIER EFFECT FOR SMALL SIGNAL AMPLIFICATION AND CONVERSION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 22,  
26 Nov 83 (manuscript received 19 Sep 83) pp 1396-1400

AGEYEV, Yu. I., AKPEROV, M. M., KOBAKHIDZE, K. Z., NEBUCHINOV, M. V.,  
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[Abstract] It is possible to use thermocouples operating as heat pumps with small temperature gradients to control elements whose properties are temperature dependent. This enables the construction of a number of electrical and optical signal transducers. The cooling or heating gain of a thermocouple used as a heat pump is proportional to the ratio of the cold or hot junction temperature to the temperature drop across the thermocouple. As this temperature gradient becomes quite small, the efficiency of such converters theoretically rises without limit. Under these conditions, the thermocouple can control elements with a metal--semiconductor phase transition, posistors or thermistors with large temperature coefficients of resistance, i.e., any device whose properties change sharply in a narrow temperature range. This paper analyzes simple circuits for small signal amplification, frequency conversion and detection. The gain of one such amplifier is plotted as a function of the input signal using various metal--semiconductor phase transition devices; the detection gain is plotted as a function of the input signal for a posistor and a metal--semiconductor phase transition device. Gains on the order of 100 and more were obtained with the latter. While such devices have the advantage of electrically isolating the input from the output, the speed is governed primarily by the rate of the thermal processes and is approximately inversely proportional to the square of the thermocouple branch length; it is presently limited to tens of milliseconds, though with the transition to film technology, it may increase by a few orders of magnitude. Figures 3, references 8 Russian.  
[15-8225]



DETECTING OPTICAL POLARIZATION OF NUCLEI IN SEMICONDUCTORS WITH SUPER-  
CONDUCTING QUANTUM INTERFEROMETER

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 22,  
26 Nov 83 (manuscript received 23 Jul 83) pp 1377-1381

VLASENKO, L. S., ZAVARITSKIY, N. V. and FLEYSHER, V. G.

[Abstract] The first use of a superconducting quantum magnetic flux meter (SKIMP) to detect nuclear spin polarization as a result of optical pumping of a silicon crystal is reported. Nuclear magnetic resonance was used to identify the nature of the light-induced magnetism. The configuration of the experimental set-up was as follows: a superconducting solenoid 13 mm in diameter and 10 cm long produced a constant magnetic field which was varied between 0.1 and 30 Gs. The earth's field was attenuated by an outer magnetic shield down to a level of  $5 \cdot 10^{-2}$  Gs. Single silicon crystals cut in the form of a cylinder 6 mm in diameter and 10 mm high were used as samples in the center of the cylindrical SKIMP. The silicon contained radiation defects with a concentration of  $5 \cdot 10^{16} \text{ cm}^{-3}$  produced by neutron irradiation. Nonequilibrium nuclear magnetization of the sample was achieved by illuminating it at 77 °K with the unpolarized light from a 1 kW incandescent lamp in a constant magnetic field of about 300 Gs for one to two hours. The exposure of the electron spin system of the semiconductor to light in a magnetic field was accompanied by a decrease in the temperature of the  $^{29}\text{Si}$  nuclei of the lattice. The long spin-lattice relaxation time of  $^{29}\text{Si}$  nuclei (more than three hours at 77 °K) made it possible to transfer the samples to the SKIMP and conduct long term measurements at a low spin temperature. The use of a calibration coil permitted the determination of the magnetic moment of the sample and the degree of polarization of the nuclear moments, which takes place with the illumination; based on measurements of four samples, this proved to be  $3 \cdot 10^{-3}$  to  $5 \cdot 10^{-3} \%$ , which for a 1 Gs field corresponds to a spin temperature of  $2 \cdot 10^{-4}$  °K to  $5 \cdot 10^{-4}$  °K. The use of such instruments as the SKIMP can also prove to be useful for direct study of electron spin polarization processes. The authors are grateful to P. L. Kapitsa, A. I. Shal'nikov and B. P. Zakharchen for their attention and discussions, as well as N. A. Nikitin for technical assistance with the work. Figures 2, references 6: 4 Russian, 2 Western.  
[15-8225]

NEW PHASE TRANSITION IN Si AND GaAs EXPOSED TO PICOSECOND LASER PULSES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 22  
26 Nov 83 (manuscript received 8 Sep 83) pp 1373-1376

ALFEROV, Zh. I., KOVAL'CHUK, Yu. V., POGOREL'SKIY, Yu. V., SMOL'SKIY, O. V.,  
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[Abstract] Experimental data indicates that it is sufficient for the onset of fusion on a time scale of  $10^{-10}$  seconds to heat a semiconductor to the melting point. The melt is formed only when the energy imparted to the semiconductor exceeds the latent heat of fusion. The entire heated region then changes into the melt without forming the nucleus of a new phase, which confirms the capability of substantially overheating a chip with a short laser pulse. This and other arguments in favor of the hypothesis of the existence of a new phase transition point in Si and  $A^3B^5$  below the formation point of the ordinary metallic melt are adduced. This nonmathematical treatment is essentially a brief review of relevant experimental data supporting the existence of a new phase transition point. The authors are grateful to V. L. Gurevich and Ye. L. Portnoy for their useful discussions. Figures 2, references 9: 4 Russian, 5 Western.  
[15-8225]

IMPACT OF WEAK ELECTRIC FIELD ON PHOTOCONDUCTIVITY OF MODIFIED VITREOUS  
 $As_2Se_3$

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 22  
26 Nov 83 (manuscript received 9 Sep 83) pp 1371-1373

ABDULGAFAROV, S. Ye., AVER'YANOV, V. L. and LYUBIN, V. M., Technical Physics  
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[Abstract] Nickel-modified (with a concentration of up to 10 at.%) films of  $As_2Se_3$  0.3 to 0.5 micrometers thick were excited by an He-Ne laser modulated at a frequency of 200 Hz in order to study the photoconductivity. The latter is plotted as a function of the applied voltage for temperatures of 25°C and 125°C. At the former room temperature, the photoconductivity initially rises in step with the increase in the electric field, goes through a maximum and then falls off sharply. At 125°C, the rising portion of the curve is practically eliminated, and the drop in the photoconductivity begins immediately. This behavior is observed at voltages plotted between values of  $\log(U)$  (in volts) of 0.2 and 2.0. These aspects of the photoconductivity are apparently best treated from the standpoint of the existence of drift and recombination barriers in transition metal (Ni, Fe, Mo)-modified  $As_2Se_3$  for the nonequilibrium charge carriers. Such barriers are more clearly manifest in

these modified materials because of statistical fluctuations in the arrangement of the impurity atoms, which produces a random potential relief, which modulates the edge of the energy bands, on analogy with strongly compensated semiconductors. The decisive factor in the electric field intensity range where the rise in the photoconductivity is observed at 25°C is the decrease in drift barriers for the majority carriers. An increase in temperature apparently has a greater impact on recombination processes than on majority carrier drift. Figure 1, references 8: 6 Russian, 2 Western.  
[15-8225]

# IMPACT OF LASER RADIATION ON OPTICAL PROPERTIES OF POLYMER LIQUID CRYSTAL IN PHASE TRANSITION RANGE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 22, 26 Nov 83 (manuscript received 13 Jun 83) pp 1349-1353

IVANOV, S. A., YAKOVLEV, I. A., VETROV, V. Yu., KOSTROMIN, S. G. and SHIBAYEV, V. P., Moscow State University imeni M. V. Lomonosov

[Abstract] Polymer liquid crystals have the capability of retaining or "freezing" a particular oriented structural state at a temperature below the glass point if the polymers are cooled in the presence of an external electric or magnetic field. Such highly oriented films are of considerable interest in information recording and storage. This possibility is checked experimentally in a study of the influence of focused laser radiation on the optical properties of a nematic liquid crystal polymer, PA-5 polyacrylate with cyandiphenyl mesogenous groups incorporated in the lateral branch structures of the macromolecules, close to the point of the phase transition from the liquid crystal state to an isotropic melt ( $T_{trans} = 106.0^\circ\text{C}$ ). The attenuated output from an He-Ne 10 m W laser was focused on a 50 micrometer thick sample in a temperature controlled cell ( $\pm 0.1^\circ\text{C}$ ); the laser beam diameter was 70 micrometers. With the exposure of a homeotropically oriented sample in a 500 Hz AC electric field to such laser radiation at more than 80 to 130 W/cm<sup>2</sup>, nonlinear refraction was detected in a temperature range of  $T - T_{trans} = +0.25$  to  $1.25^\circ\text{C}$ ; increasing intensity led to a widening of the transiting beam and a distortion of its profile. The broadening was a function of the temperature and incident power. When the polymer surface was observed in unfocused laser light at a point of previous exposure to a focused beam, a dark contrast spot was observed when  $T - T_{trans} = 0$  and the power was 200 W/cm<sup>2</sup>; the spot diameter was two to three times greater than the focused beam diameter. The spot disappeared when an AC voltage was applied to the sample electrodes. When  $T - T_{trans} = -1^\circ\text{C}$ , the spot was preserved for two to three hours without any significant reduction in contrast. The appearance of this optical inhomogeneity is due to the formation of the isotropic phase. Subsequent cooling produces

a disoriented, strongly light scattering texture at this point. The application of an electric field restored the homeotropic orientation at places where it was previously disrupted. A photograph is shown of letters recorded in this fashion, where the line thickness is about 100 micrometers. Figures 2, references 8: 6 Russian, 2 Western.  
[15-8225]

#### NONCUBIC MAGNETIC ANISOTROPY IN YSmLuCaFeGe GARNET FILMS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 10, Oct 83  
(manuscript received 31 May 83) pp 3086-3090

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[Abstract] An experimental study of YSmLuCaFeGe garnet films was made for the purpose of determining the dependence of their noncubic magnetic anisotropy on the technological conditions. Three series of such films were deposited on  $Gd_3Ga_5O_{12}$  substrates with (111)-orientation. All specimens contained the same amounts of garnetizing oxides and somewhat more Ca than Ge, but different amounts of  $PbO-B_2O_3$  solvent in each series so that each of the three melts had a correspondingly different saturation temperature. Films were deposited at 869.5-920°C at rates of 0.1-0.81  $\mu\text{m}/\text{min}$  with the substrate rotating at 200 rpm; and then subcooled by  $\Delta T = 1.5-23^\circ\text{C}$ . Their composition was measured by microanalysis with an electronic probe, their thickness (1.4-4  $\mu\text{m}$ ) was measured by the interference method, and their saturation magnetization (625-800 Gs) was measured by the Cullen-Josephs method. The constant of uniaxial magnetic anisotropy was determined from ferromagnetic-resonance measurements and Cronmeyer relations (Proc. AIP Conf. Vol 18, 1974). Growth-induced magnetic anisotropy was studied with the aid of heat treatment, assuming random distribution of ions at crystal lattice sites following thermal diffusion. The results have revealed an intricate dependence of uniaxial magnetic anisotropy on the film annealing temperature, the anisotropy constant first increasing slightly from an already high value at 700°C to a peak at 1000°C and then dropping rapidly to zero at 1200°C. This trend is attributed to the existence of two anisotropy components, a positive uniaxial one and a negative "easy plane" one. The dependence on the film deposition temperature was found to be much simpler, the anisotropy constant decreasing consistently with increasing deposition temperature. It was also found to increase consistently with increasing rate of film growth. The authors thank S. Krupicka, G. A. Smolenskiy and V. A. Bokov for support and helpful discussions, also D. Zemanova for performing the chemical analysis. Figures 4, references 18: 2 Russian, 16 Western.  
[13-2415]



POLARIZATION OF PARAEXCITON LUMINESCENCE IN  $\text{Cu}_2\text{O}$  CRYSTALS IN MAGNETIC FIELD

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 10, Oct 83  
(manuscript received 12 May 83) pp 3002-3008

GASTEY, S. V., IVCHENKO, Ye. L., PIKUS, G. Ye., SOKOLOV, N. S. and  
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[Abstract] Cuprous oxide was the first material revealing the existence of excitons and it has become the model material for study of Mott-Wannier excitons. In this connection, magnetically induced circular polarization of paraexcitons in  $\text{Cu}_2\text{O}$  crystals offers excellent means of reliably determining to what extent mixing of wave functions contributes to luminescence associated with transitions between nondegenerate states without participation of Zeeman splitting of the initial state and the final state. For an experimental study of this problem specimens of  $\text{Cu}_2\text{O}$  crystals were grown by the hydrothermal method from copper hydroxide and then immediately immersed in liquid helium at  $T = 1.6$  K. Luminescence was excited by means of an argon laser ( $\lambda = 5145 \text{ \AA}$ ) and a magnetic field of  $H = 6$  T intensity was produced by means of a superconducting solenoid. The luminescence, observable along the magnetic field, was analyzed with a DFS-12 spectrometer, its  $I_+$ - $I_-$  signals with magnetically induced circular polarization being coupled out by an acoustooptic quartz modulator with polaroid film. The results have revealed a phononless orthoexciton line A and its three phononic recurrences

$A_1$  ( $86 \text{ cm}^{-1}$ ) with excitation of  $\Gamma_5^-$  or  $\Gamma_{25}$  phonon,  $A_2$  ( $110 \text{ cm}^{-1}$ ) with excitation of  $\Gamma_3^-$  or  $\Gamma_{12}$  phonon,  $A_3$  ( $150 \text{ cm}^{-1}$ ) with excitation of  $\Gamma_4^-$  or  $\Gamma_{15}$

phonon, also phononic recurrences of a paraexciton line B:  $B_1$  with excitation of  $\Gamma_3^-$  phonon and  $B_2$  with excitation of  $\Gamma_4^-$  phonon. The phononless paraexciton line B ( $6125 \text{ \AA}$ ) is forbidden in a crystal with  $q \parallel H \parallel [111]$  orientation. The results are interpreted first on the basis of phenomenological theory for a  $\Gamma_2^+$  paraexciton from three optical transitions corresponding to B,  $B_1$ ,  $B_2$  bands ( $B_1$ -band transition without a magnetic field allowed only with excitation of  $\Gamma_5^-$  phonon,  $B_2$ -band allowed only in a magnetic field) and then on the basis of microscopic theory for  $\Gamma_6^+$  and  $\Gamma_7^+$  conduction bands with negligible spin-orbital mixing of wave functions in the  $\Gamma_6^+$  band when  $k = 0$ . The authors thank A. A. Kaplyanskiy for many creative discussions and valuable comments. Figures 3, references 7: 5 Russian, 2 Western.  
[13-2415]



ELECTRON-MICROSCOPIC MICROSTRUCTURAL EXAMINATION OF GLASSY Ge-Se  
SEMICONDUCTORS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 10, Oct 83  
(manuscript received 19 Jan 83, after final editing 8 Apr 83) pp 2923-2929

MARIKHIN, V. A., MAMONTOVA, T. N. and NIKITIN, V. A., Institute of Engineering  
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[Abstract] The microstructure of glassy Ge-Se semiconductors was studied under an electron microscope, synthetic  $\text{GeSe}_2$  being an important representative of the Ge-Se system. Specimens of this material had been produced by heating a mixture of Ge with electrical resistivity of 50 ohm·cm and 99.999% pure Se in a T-40-600 tubular vacuum furnace to 1000°C at a rate not exceeding 150°C/h and holding at this temperature for 40-50 h prior to quenching the melt at a rate within 100-200°C/s. Examination under a JEM-5Y microscope with an acceleration voltage up to 100 kV revealed microdomains (200-300 Å) and minidomains (1000-2000 Å) forming macrodomains (3-4 μm). This confirms the hypothesis, based on earlier laser spectrophotography and luminescence measurements, that these glassy materials are heterogeneous with inclusions of fine imperfect crystallites. The replicas indicate also that microdomains with unsaturated bonds and carrying electric charges may be forming during segregation of phases. Figures 6, references 12: 6 Russian, 6 Western. [13-2415]

## ELECTRICITY AND MAGNETISM

### INSTABILITY OF COLLAPSING CYLINDRICAL SHELL DURING MAGNETIC ENERGY DENSITY BUILD-UP

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 22, 26 Nov 83 (manuscript received 19 Jul 83) pp 1360-1364

PAVLOVSKIY, A. I., DOLOTENKO, M. I., KOLOKOL'CHIKOV, N. P., BYKOV, A. I., YEGOROV, N. I. and TATSENKO, O. M.

[Abstract] A shaped explosive charge type magnetic field generator was used to produce a collapsing shell around a megagauss magnetic field. The initial shell diameter was 139 mm. The dynamics of the shell shape change was studied by transilluminating the magnetic shaped charge generator with bremsstrahlung from a nonferrous pulsed betatron. X-ray photographs taken perpendicular to the magnetic field generator axis show the collapse of the shell between 14.5 microseconds into the process, when the magnetic field in the 33 mm diameter cavity was 2.7 MGs and 16.7 microseconds, when the cavity diameter was 18 mm and the field in it was 6.2 MGs. This paper demonstrates for the first time that the instability of the motion of the internal surface of a shell compressed by an ultrastrong magnetic field limits the growth of the magnetic energy density. Figures 3, references 5: 2 Russian, 3 Western.  
[15-8225]

UDC 537.811.1

### EXCITATION OF QUASI-STATIC MAGNETIC FIELDS IN AXIAL STRUCTURES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 2, Sep 83 (manuscript received 3 Jan 83) pp 344-346

KARPENKO, A. G., LOBACHEVSKIY, L. A. and MIGULIN, V. V., Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences, Moscow

[Abstract] A quasi-static magnetic field excited in air above the sea surface by a quasi-steady alternating electric current flowing through an insulated conductor in water, with water serving as the "return" path, has been found to have not a dipole structure as in the case of a closed current loop

but an axial structure as in the case of a straight wire. The intensity of such a magnetic field in air, beyond the water surrounding the conductor, is determined by the current in the conductor only and does not depend on the current in water. Measurements confirm theoretical calculations very closely, namely that the magnetic field intensity decreases with increasing distance from the conductor according to the inverse-square rather than the inverse-cube relation. This can be of practical significance for radiating stronger quasi-static magnetic fields, especially at low frequencies. Article was presented by Academician A. M. Prokhorov on 22 December 1982. Figure 1.  
[28-2415]

INERTIAL AND SHEAR FLOW

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 2, Jan 84  
(manuscript received 5 Jan 83) pp 280-283

ALEKSANDROV, V. V. and SHMYGLEVSKIY, Yu. D., Computer Center, USSR Academy of Sciences, Moscow

[Abstract] Inertial flow of a fluid with rectilinear uniform motion of particles is analyzed on the basis of equations describing free fall of an ideal fluid and shear flow of a viscous fluid, with the gravitational acceleration assumed to be some function of the altitude  $z$ . The longitudinal velocity component is some function of altitude  $u = U(z)$ . The transverse component and the vertical component are both functions of the longitudinal one, namely  $v = \phi(u)$  and  $w = \psi(u)$  respectively. Distributions of pressure and of velocity components are calculated by reduction of the fundamental equations to ordinary differential ones with change from the Hamiltonian operator to Lagrangian variables, and subsequent linearization. The special case of an incompressible fluid and the more general case of a compressible fluid are considered. Calculations are shown for two examples of flow. The first example is  $\phi = 2\sqrt{u}$  and  $\psi = 0$ . The second case represents a geophysical fluid such as a high-altitude cloud with particles in apparently irregular motion and with shear flow characterized by 10 arbitrary constants. The authors thank A. G. Kulikovskiy for friendly discussions. Article was presented by Academician A. A. Dorodnitsyn on 30 December 1982. Figures 2.  
[25-2415]

NEW LASING FERROELECTRIC MATERIAL  $\text{Pb}_5\text{Ge}_3\text{O}_{11}-\text{Nd}^{3+}$

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 270, No 6, Jun 83  
(manuscript received 10 Jan 83) pp 1373-1376

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Central Institute of Optics and Spectroscopy, GDR Academy of Sciences, Berlin

[Abstract] Only four ferroelectric lasing crystal matrices are among the 260 known ones, and finding new ones is of interest to research in solid-state physics, quantum electronics, and acoustics. A study was made to achieve lasing in  $\text{Pb}_5\text{Ge}_3\text{O}_{11}-\text{Nd}^{3+}$ , a trigonal ferroelectric crystal, the feasibility having been established by the results of earlier luminescence spectrum analysis. Single crystals of this material were synthesized by the Czochralski method from optical-grade lead germanate with high concentration of neodymium ions, under precisely controlled physico-chemical conditions including compensation of excess charge carriers with potassium ions. Lasing was excited at 77 and 300 K with a low energy threshold on the  $^4\text{F}_{3/2} \rightarrow ^4\text{I}_{11/2}$

inter-Stark transition. This new laser source is an optically positive crystal with one center and ordered structure, its transparency window is 0.5-4  $\mu\text{m}$ , its melting point and Curie point are about 1010 and 450 K respectively. The results of this study confirm the feasibility of eeo phase synchronism, but conditions for converting laser radiation from  $\text{Nd}^{3+}$  ions to second-harmonic radiation are favorable only at wavelengths  $\lambda \geq 1.7 \mu\text{m}$ .

Article was presented by Academician B. K. Vaynshteyn on 30 Dec 1982.

Figures 2, table 1, references 15: 8 Russian, 7 Western.

[10-2415]



## HIGH-Q OPEN RESONATOR STRUCTURES WITH SPARSE SPECTRUM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 1, Sep 83  
(manuscript received 21 Oct 82) pp 94-97

KURAYEV, A. A., NEFEDOV, Ye. I., SLEPYAN, A. Ya. and SLEPYAN, G. Ya.,  
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Moscow

[Abstract] The feasibility of producing coaxial open resonator structures with high Q-factor and sparse spectrum is considered, the gist being to use magnetic modes with higher-order radial index ( $H_{mn}$ ,  $n \neq 1$ ). Such modes are neither exactly space modes nor exactly boundary modes but combine some characteristics of both. The principle of operation of such a resonator is cutting off a waveguide mode between two critical sections. The heat loss, characterized by the frequency-independent parameter  $\sigma = \delta k Q$  ( $\delta$  - field penetration depth in metal,  $k$  - wave number,  $Q$  - ohmic storage factor), is calculated approximately by using the Shukin-Leontovich impedance boundary conditions and applying the perturbation method to the surface impedance of the mirror material. For comparison, the heat loss in an open resonator structure operating with boundary modes is calculated analogously. Theoretical estimates agree fairly closely with experimental data. A frequency-tunable high-Q open resonator should be realizable by resorting to a biconic structure, with the outer conductor slightly tapering and the inner conductor movable. Article was presented by Academician A. M. Prokhorov on 14 October 1982. Figure 1, references 3: 2 Russian, 1 Western.  
[9-2415]

PLASMA IN DIVERTER DURING INTENSE RECYCLING

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 270, No 6, Jun 83  
(manuscript received 2 Mar 83) pp 1376-1380

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[Abstract] Diverters are being developed for plasma scrubbing and pumping in future helium reactors, with plasma flowing along the tokamak walls being extracted parallel to the magnetic field into a special compartment where it is cooled and neutralized by the diverter plates. For design and performance calculations, made before by intricate numerical methods, an analytical model is proposed here applicable to deuterium-tritium plasma under conditions of intense recycling. Selected as the physical model is a poloidal diverter where charged particles return to the plasma as atoms after neutralization at the plates and here again become charged. This cycle is described by one-dimensional equations of kinetics for molecules and for atoms, taking into account ionization and dissociation, and equations of continuity and heat conduction for the plasma. Heat and charge transfer across the magnetic field is negligible so that only transfer along the magnetic field needs to be considered. These equations are supplemented with the equation of motion for the plasma as an entity along the magnetic field, with friction between ions and atoms during charge transfer. The boundary conditions are stipulated in terms of integral heat and particle fluxes. The system of equations is solved on the basis of two-velocity distribution functions. Numerical results as well as curves describing steady-state and transient characteristics have been obtained by this method for a diverter for a 60 MW tokamak reactor of the INTOR scale. The authors thank Academician B. B. Kadomtsev and V. I. Pistunovich for valuable comments. Article was presented by Academician B. B. Kadomtsev on 25 January 1983. Figures 2, references 7: 1 Russian, 6 Western.  
[10-2415]

## DYNAMICS OF PLASMA CORONA ON SPHERICAL TARGETS IRRADIATED BY LASER

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA  
 AKADEMII NAUK SSSR: VZAIMODEYSTVIYE LAZERNOGO IZLUCHENIYA S TERMOYADERNYMI  
 MISHENYAMI in Russian Vol 133, 1983 pp 146-188

ZAKHARENKOV, Yu. A., ZOREV, N. N., RUPASOV, A. A., SKLIZKOV, G. V. and  
 SHIKANOV, A. S.

[Abstract] Interaction of laser radiation and plasma corona on a target is analyzed on the basis of experimental data from the "Kal'mar" laser facility and theoretical relations describing the plasma corona hydrodynamics. Important factors determining the dynamics of plasma corona are deformation of the plasma density profile and acceleration of charged particles. The hydrodynamic parameters and the effect of initial perturbations are evaluated, accordingly, on the basis of data on evolution of the density profile, those data having been obtained with a special diagnostic optical system including a KDP crystal and a Jamin interferometer. Studies of plasma dynamics within the region of critical radiation flux density were made by photographic recording with space and time resolution, the second-harmonic emission spectrum yielding the propagation velocity of that region and the  $\frac{3}{2}\omega_0$  emission spectrum with two components on both sides of the  $\frac{2}{3}\lambda_0$  wavelength yielding the electron temperature of the plasma corona. An ion collector with negative grid electrode and an ion collector with negative bias around a spherical target, with an electrostatic ion analyzer and a secondary-emission multiplier behind the second collector were used for determining the energy spectrum and the charge content of ions. The velocity distribution function of spherically dispersing ions was determined from oscillograms of two collector signals, with the aid of schlieren photography or interferogram processing for dispersion of fast ions. An interpretation of the results in terms of a jet mechanism of particle acceleration has explained the incomplete coverage of the target surface with emitted fast ions, the emission of gas ionizing particles within an almost cylindrical beam not coinciding with any of the heating beams, the high velocity of particles, one order of magnitude higher than the thermal velocity of dispersing ions, and the large fraction of energy available in each group of accelerated particles sufficient for producing a shock wave in the ambient gas. Such an interpretation also reveals a correlation between acceleration regions of the target and its regions of most intense emission of second-harmonic heating radiation. Another item of interest is resonant acceleration of ions in the laser plasma, which has been analyzed in the linear approximation for the electric field intensity and taking into account development of aperiodic instability. Figures 35, tables 1, references 119: 59 Russian, 60 Western.

[26-2415]

## HEATING AND IMPLOSION OF SPHERICAL TARGETS IRRADIATED BY LASER

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA  
AKADEMII NAUK SSSR: VZAIMODEYSTVIYE LAZERNOGO IZLUCHENIYA S TERMOYADERNYMI  
MISHENYAMI in Russian Vol 133, 1983 pp 51-145

VASIN, B. L., YEROKHIN, A. A., ZOREV, N. N., KOLOGRIVOV, A. A., RUPASOV, A. S.,  
SKLIZKOV, G. V. and SHIKANOV, A. S.

[Abstract] The state of the art in implosion of shell targets by means of laser irradiation is reviewed, with emphasis on methods and results of evaluating the target compression parameters. The process begins with absorption of laser energy and heatup of the target, much information being provided by x-radiation from the corona region of the target plasma. The "Kal'mar" 9-channel laser facility with a series-parallel amplifier system has been developed and subsequently modified for experimental study of laser-fusion processes in targets. It consists of a YAG master laser with space filters and modulation, a short-duration pulse shaping circuit, preamplifier stages, power amplifier stages, beam focusing and homing optics, and a vacuum chamber with diagnostic instruments. Spectral analysis and synthesis of laser radiation with the aid of a Fabry-Perot interferometer have yielded data on the spectrum evolution and the intensity-energy characteristics including time parameters and directivity as well as contrast. The optical system has been optimized on the basis of scattering, nonuniformity, and instability data and their evaluation according to the B-integral theory. Experiments were performed and correlated with theoretical heat balance relations regarding the dynamics of strongly ionizing shock waves and their propagation under conditions of ionization and dissociation. Important in the methodology of determining the parameters of plasma and shock waves is selection of the ambient gas, preferably deuterium or hydrogen, and its pressure as well as the length of observation time and means of recording the instantaneous location of a shock wave. Evaluation of measurements includes estimation of systematic errors. Absorption of laser energy by shell targets is determined calorimetrically on the basis of heat balance, spherical targets being most suitable as model, absorption of plasma energy is determined on the basis of shock wave propagation in atomic gas. A special optical system has been designed for measuring scattered and reflected hot radiation as well as interaction between laser radiation and plasma corona, particularly interesting being the region of critical radiation flux density and emission of the  $3/2$  harmonic. Other results of x-radiation experiments with the "Kal'mar" facility include the spectrum of continuous x-radiation, obtained by photographing the plasma with space resolution and processing the x-ray obscurograms, then profiles of electron temperature and concentration in the plasma corona, the rate of target compression and parameters of the compressed target core. Figures 47, tables 5, references 218: 110 Russian, 108 Western.  
[26-2415]



## CONTROL COMPUTERS AND AUTOMATION SUBSYSTEM EQUIPMENT IN 'DEL'FIN' FACILITY

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA  
 AKADEMII NAUK SSSR: VZAIMODEYSTVIYE LAZERNOGO IZLUCHENIYA S TERMOYADERNYMI  
 MISHENYAMI in Russian Vol 133, 1983 pp 19-50

ALLIN, A. P., BELEN'KIY, Yu. M., BORZYAK, Yu. V., BYKOVSKIY, N. Ye.,  
 GRIGOR'YEV, V. Ye., GUSYATNIKOV, B. S., DOROSHKEVICH, I. L., IVANOV, V. V.,  
 KUCHINSKIY, A. G., SAVCHENKO, V. M., SEMENOV, V. F., SENATSKIY, Yu. V.,  
 SKLIZKOV, G. V., SUBBOTIN, L. K., TARANCHUK, V. B., SHPILEVOY, B. N.,  
 YUZHAKOV, A. N. and YAKUSHEV, A. K.

[Abstract] The power equipment of the "Del'fin" laser facility contains a  $10^7$  J capacitor bank divided into four identical sections feeding a power preamplifier and three output stages each, with 328 IFP-20000 flash tubes designed to produce 2.5 kJ laser radiation. The system for controlling and automating laser experiments, modeled after the SHIVA system (Lawrence Livermore Lab.), includes a computer complex in the central console and the sequential ring bus, with CAMAC peripheral stations inside the optical chamber including three microcomputers ("Polon", "Nuclear Enterprise", "HENESA"). The control computer with a 28 K memory is linked to a KE-11V arithmetic unit, the subsidiary computer with a 28 K memory is linked to the CAMAC stations and to a terminal DECWRITER-II. The system crate contains a 9030/32 interface, a 3992 driver for the sequential bus, and a 064 LAM GRADER interrogation processing module. The computer complex also includes an RSX-11M multiprogram multipurpose real-time disk operating system which uses standard DECNET-11 software and includes a translator from MACRO-11 assembler language to FORTRAN-4, BASIC-11, COBOL and a few other languages. The laser power is automatically controlled through the CAMAC stations according to a main program as well as dialog maintenance programs (BCE, KASKN, KASN, DIAL, STRB, MODB, BKYM, STRB, BKYB, BKY) and measurement programs (CONTRO, CNTR0,KOD) designed to ensure simple and reliable high-speed control of laser experiments. All alignment and regulation of the laser facility is automated through optical channels (aligning LTI-501 laser, collimators, lenses, auxiliary optics) and servomechanisms (coordinate photoreceiver--homing signal module--step motors) designed for positioning and orientating mirrors 80 mm and 30 mm in diameter. The target is also automatically controlled by a system which feeds it into the focal space in any one of four modes of operation: 1) with signals from high-precision adjustable motor resistors; 2) with signals from measuring coils; 3) with computer instructions; 4) with signals from terminal cutout switches driving the target into extreme position along any of three space coordinates. Proposals for further development and improvement of the automatic control system are use of SM-4 computers with  $12^4$  K memory on the upper level, storage on magnetic tape and disks, analog-to-digital conversion, and display panels, also introduction of standard DECNET-11 M/S software for interfacing the central computer with an RSX-11M operating subsystem and local computers with RSX-11S operating subsystems, simplification and automation of optical communication lines for high-density digital data transmission over low-loss fibers. Figures 31, tables 2, references 25: 18 Russian, 7 Western. [26-2415]



## STUDIES OF AMPLIFIER MODULE IN 'DEL'FIN' FACILITY FOR HEATING THERMONUCLEAR PLASMA

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA  
 AKADEMII NAUK SSSR: VZAIMODEYSTVIYE LAZERNOGO IZLUCHENIYA S TERMOYADERYMI  
 MISHENYAMI in Russian Vol 133, 1983 pp 3-18

BASOV, N. G., VASIN, B. L., GALICHIY, A. A., DANILOV, A. Ye., IVANOV, B. Yu.,  
 KALASHNIKOV, M. P., KRUGLOV, B. V., MIKHAYLOV, Yu. A. OSETROV, V. P.,  
 PUZYREV, V. N., RODE, A. V., SAVCHENKO, S. M., SKLIZKOV, G. V., SOLODKOV, V.M.,  
 FEDOTOV, S. I., TSITOVICH, V. A. and SHISHKINA, L. I.

[Abstract] The laser-fusion facility "Del'fin" for heating targets in a spherical radiation geometry consists of four functionally independent power amplifier modules, each capable of forming 54 laser beams 45 mm in diameter and variously grouping them together. A module consists of a linear preamplifier, three amplifiers and three output stages in cascade, also spherical and cylindrical intermediate collimators containing space filters with circular and slot diaphragms respectively. Each amplifier contains cells with active elements splitting the incident laser beam successively into 2, 6, 18, 54 and these 54 component beams are variously combined in the output stages. The focusing system has been designed with a 1:2 aperture ratio for beam divergence angle of the order of  $10^{-3}$  rad, illuminance nonuniformity not exceeding a few percent of the mean illuminance, and tautochromism of all component beams not worse than 0.5 cm, also with automatic target search and homing as well as beam tracking along three space coordinates. Each focusing channel consists of a multiprism mirror, a long-focus first lens, a corrective and diverting plate, a rotatable mirror, and a short-focus camera lens with 1:26 aperture ratio concentrating the radiation on the target. These components are capable of withstanding hundreds of laser flares at a flux power density within the  $1-3 \text{ GW/cm}^2$  range (strength of glass) and are assembled so as neither to cause self-excitation of laser equipment by light reflected by their surfaces and by the target surface nor to weaken the radiation contrast. The performance of such an amplifier module was studied experimentally in various modes of operation such as heating plasmas which have formed during laser irradiation of thin foils or shell targets. The main object was not only to evaluate the efficiency of heating 0.5-10  $\mu\text{m}$  thick aluminum foil but also to establish the relation between parameters of the plasma target and parameters of the component laser beams. The radiation intensity distribution was measured and isodensitograms were recorded for analysis of the radiation wavefront structure at successive critical sections along the path. A special instrument PIR-1 had been developed for this purpose, facilitating the analysis of laser radiation characteristics in the caustic zone of the long-focus lens as well as the measurement of the beam divergence angle. Laser pulses were recorded by means of coaxial photodiodes, for analysis of their waveform. Plasma heating was also monitored spectrographically, on the basis of multicharge ions, with the aid of a plane quartz crystal of 10 $\bar{1}0$  orientation. Figures 21, table 1, references 30: 20 Russian, 10 Western.

[26-2415]

UDC 535.417

HOLOGRAPHIC IMAGE SUBTRACTION BY RECORDING IN FOURIER PLANE AND SPACE  
FILTRATION WITH THIN LIGHT BEAM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, Sep 83  
(manuscript received 17 Mar 83) pp 365-369

KLIMENKO, I. S., MALOV, S. N. and RYABUKHO, V. P., Moscow Institute of  
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[Abstract] A simple holographic method of image subtraction is proposed which ensures a sufficiently high brightness of the difference image without use of phase shifters. Its gist is double exposure of the Fourier hologram on which the two images have been recorded with a small relative transverse shift, followed by its illumination with a thin laser beam for space filtration and subsequent optical Fourier transformation of the reconstructed field. The method is based on the theory of a diffusely illuminated transparency and the interference pattern of coherent light in the Fourier plane. The method was tested experimentally on a piece of chalk whose surface microrelief had been altered mechanically during the time between two successive exposures. Measurements with a standard optical gauge revealed formation of the difference image with insignificant background noise but rather appreciable speckle noise, the latter limiting the resolution to only 0.05 mm unless reduced by further filtration with a laser beam of oblong cross section. Article was presented by Academician A. M. Prokhorov on 9 March 1983. Figures 2; references 4 Western.  
[28-2415]

UDC 535.853

MICROSPECTROPHOTOMETER FOR CRYSTAL ANALYSIS BY ABSORPTION REFLECTOMETRY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 1, Sep 83  
(manuscript received 21 Sep 82) pp 97-100

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[Abstract] A recording polarization microspectrophotometer using transmitted or reflected light has been built for optical analysis of crystals with the specimen in the same position for both modes of measurements. The equipment

consists of a main light source, a diffraction monochromator, a beam splitter and delay line (lens, diaphragm, vibrating biprism, V-mirror and spherical mirror, another diaphragm, another lens), a reflection-transmission switching  $45^\circ$  mirror, a polarizer, a small cubic prism with specular diagonal plane for reflection spectrophotography or a large cubic prism with semitransparent diagonal plane for transmission spectrophotography with an auxiliary light beam coming from a lateral source through a diaphragm and the switching mirror, and around either prism a reference objective with mirror behind, a photocathode receiver tube, an ocular behind a rotatable analyzer and a flappable prism, and a main objective followed by a microscope stage with the specimen, then a condenser, and a switching  $45^\circ$  mirror reflecting into it light from a second auxiliary source with diaphragm and passing light to a second photocathode receiver tube. Output signals from both photoreceivers are recorded by the same instrument. Both cubic prisms are placed inside an opaque luminaire. This microspectrophotometer was used experimentally on  $0.25\text{--}2.66\text{ }\mu\text{m}$  thick square single-crystal wafers of  $\text{K}_2\text{Pt}(\text{CN})_4\text{Br}_{0.3}\cdot 2.6\text{H}_2\text{O}$ .

Their reflection and transmission spectra were measured, and the spectral characteristics of their refractive index and other optical properties were determined and compared with theoretical ones. The accuracy of measurements decreases with decreasing crystal thickness, owing to stronger interference effects. Article was presented by Academician V. P. Linnik on 21 September 1982. Figures 3, references 4: 3 Russian, 1 Western.  
[9-2415]

UDC 532:539.2

#### NATURE OF POLARIZED VIBRONIC SIDEBANDS OF BIEXCITON ABSORPTION IN $\alpha$ -OXYGEN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 1, Sep 83  
(manuscript received 22 Nov 82) pp 62-64

GAYDIDEY, Yu. B., LOKTEV, V. M., OSTROVSKIY, V. S. and Academician PRIKHOT'KO, A. F., Institute of Theoretical Physics and Institute of Physics, UkSSR Academy of Sciences

[Abstract] It has been ascertained so far that absorption of light in the  $1500\text{--}13,000\text{ cm}^{-1}$  region by  $\alpha$ -oxygen in many polycrystalline substances is attributable to generation of biexcitons with small radii. It was first assumed that in all red ( $\Delta\Delta$ -transition) and ultraviolet ( $\Sigma\Sigma$ -transition) vibronic bands  $20\text{--}30\text{ cm}^{-1}$  away from strong exciton-vibron lines there are clusters of weak lines originating independent secondary small vibrational line clusters. This concept was subsequently contradicted by experimental evidence of distinct polarization of those primary line clusters that are associated with vibrations in the crystal; it is necessary to explain the rather wide frequency defect (Debye frequency  $\omega_D \approx 100\text{ K}$  in  $\alpha$ -oxygen) as well as the polarization. Such an explanation is given in accordance with the biexciton theory of absorption, with a crystal regarded as an array of

interacting molecular layers, and taking into account the relatively weak interplanar interaction. An analysis on this basis indicates consistently and convincingly that polarization of the first major satellites in exciton-vibronic bands can be associated with equipairwise components of biexciton splitting by interplanar interaction in oxygen molecules. Figure 1, references 10: 8 Russian, 2 Western.

[9-2415]

## STRESS, STRAIN AND DEFORMATION

UDC 629.12:534.1

### TRANSVERSE VIBRATIONS OF SHIP DRIVE SHAFT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 270, No 6, Jun 83  
(manuscript received 12 Jul 82) pp 1346-1350

KEL'ZON, A. S., ZOBININ, A. P., MALININ, L. M. and TROSHKOV, Ye. I.,  
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[Abstract] One problem in operation of ships in the "Varnemunde" class is excessive transverse vibration of the drive shaft. Measurements made on the "Pavlograd" steamship in this class have revealed irregular beats of slowly varying amplitude and almost constant frequency. Evaluation of experimental data and theoretical spectrum analysis indicate the presence of both forced and self-excited vibrations and deterministically varying as well as stochastically varying loads, especially hydrodynamic ones, as their likely causes. Avoidance and prevention of resonances must, accordingly take into account the operating speed range for flexible shafts and not only the fundamental but also higher-order resonances in rough water. Article was presented by Academician V. V. Novozhilov on 2 July 1982. Figures 2, table 1, references 4: 3 Russian, 1 Western.  
[10-2415]

UDC 539.3

### PROPAGATION OF FLEXURAL WAVES IN INITIALLY STRESSED NONCIRCULAR CYLINDERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 270, No 6, Jun 83  
(manuscript received 29 Jun 82) pp 1343-1345

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[Abstract] Propagation of flexural waves is considered in a compressible and transversely isotropic solid cylinder with noncircular cross section and arbitrary elastic potential under an axial load. The problem is formulated in Lagrangian coordinates which in the undeformed state coincide with Cartesian ones, it is analyzed according to the three-dimensional linearized theory of elasticity with initial strains, and it is solved with the aid of a variational principle allowing linearization of the equations of motion and of the boundary conditions at the lateral surface. The cylinder is assumed to be



infinitely long, its lateral surface to be free of stresses, and its cross section to have two axes of symmetry. The dispersion equation is derived from the condition for existence of a nontrivial solution. The general results are easily approximated in special cases and so is the analytical expression for the phase velocity of flexural waves. A cylinder with rectangular cross section is considered as an example. References: 6 Russian.

[10-2415]

## SUPERCONDUCTIVITY

DESIGN AND STUDY OF SUPERCONDUCTING NIOBIUM RESONATOR CAVITIES WITH Q OF  $10^9$  TO  $10^{10}$

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 22  
26 Nov 83 (manuscript received 28 Jul 83) pp 1368-1370

DIDENKO, A. N., ARTEMENKO, S. N., KAMINSKIY, V. L., SAMOYLENKO, G. M. and YUSHKOV, Yu. G., Scientific Research Institute for Nuclear Physics at Tomsk Polytechnical Institute imeni S. M. Kirov

[Abstract] Superconducting microwave systems fabricated under identical conditions often have different electrophysical parameters, even with careful quality control and the use of such techniques as high vacuum annealing and electrochemical or chemical polishing as well as anodizing of the surfaces. This paper ascertains the most significant factors influencing ultrahigh Q cavity fabrication from niobium having values of  $\gamma = 170, 200$  and  $400$  operating in the  $H_{011}$  mode at 9.5 GHz. Measurements show that cavities subjected to just precision mechanical machining have ultimate Q's of  $1 \cdot 10^8$  to  $3 \cdot 10^8$ ; the same cavities with electrochemical treatment of the working surfaces had stable Q's in practically all cases in a range of  $1 \cdot 10^9$  to  $1 \cdot 10^{10}$  and RF field amplitudes of 950 to 1,200 Oe (20 to 25 MV/m). In this case, such cavities with a protective coating exhibited only a slight degradation of the parameters after three months of storage in a normal atmosphere. The ultimate Q's can thus be attained without employing the labor intensive operation of high vacuum, high temperature annealing when efficient structural designs are used in conjunction with precision machining and assuring a high degree of purity of the working surfaces in all stages of fabrication, storage, assembly and test measurements. References 4: 2 Russian, 2 Western.  
[15-8225]

HEAT TRANSFER FROM PLASMA TO MICROPARTICLE. CONTRIBUTION OF CHARGE TRANSFER PROCESSES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 1, Sep 83  
(manuscript received 1 Sep 82) pp 104-108

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[Abstract] Heat and mass transfer by the mechanism of charge transfer during interaction of a dense plasma and a microparticle is analyzed without consideration of radiative and molecular processes. A relation is established between electron and ion fluxes, revealing that calculation methods for probing of weakly ionized plasmas are also applicable to strongly ionized plasmas in which fluxes of charged particles become comparable with the molecular flux. The intensities of charge and energy fluxes are determined by the space distribution of potential in the plasma and by the potential of the microparticle as well as by pairwise collisions between plasma particles of each kind (molecules, electrons, ions) and their collisions with the microparticle. The mathematical model is based on the kinetic equations for the moment of momentum and the Poisson equation for the electric potential as functions of the radial coordinate (normalized to the microparticle radius) and of the interaction energy (normalized to the plasma temperature) respectively. Expressions are derived for the electron flux and the ion flux as well as the corresponding thermal fluxes in the extreme cases of strong shielding by a thin electric double layer, strong shielding by free molecules, weak shielding, and an electrostatic probe. Quantitative results are shown pertaining to a metal microparticle in an argon plasma under typical metallurgical conditions, namely the ratio of heat transfer parameter to mass transfer parameter and the ratio of electron+ion components to molecular component of heat transfer as functions of the microparticle radius and the plasma temperature. The results indicate an appreciable contribution of charged particles to heat transfer even at low degrees of ionization. This is attributable to a larger than geometrical effective cross section for ion-microparticle collision resulting in a negative potential in a quasi-neutral plasma, especially when that cross section becomes linearly dependent on the potential, and to electron-microparticle collisions involving electrons with energy higher than the potential barrier at the microparticle surface. During recombination of electrons and ions at the microparticle surface, moreover, they release more heat than that absorbed by the molecules. Article was presented by Academician N. N. Rykalin on 27 July 1982. Figure 1, references 7: 5 Russian, 2 Western. [9-2415]

# THERMODYNAMIC APPROACH TO FRACTURE MICROMECHANICS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 10, Oct 83  
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[Abstract] There is experimental evidence that fracture of solids under load occurs upon initiation of cracks by thermal fluctuations, fracturing fluctuations being characterized by an expectancy time which decreases exponentially with increasing stress. Treatment of cracks as fractural "quanta" leads to the concept of cracking as a localized growth process following nucleation of cracks. The contradiction between this concept and experimental evidence of delocalized "diffuse" cracking can be resolved by considering the thermodynamic aspect of the cracking geometry. A comparison of the free energy  $F = E - TS$  for localized and delocalized cracking respectively reveals the factors which determine each trend, the random nature of fracturing thermal fluctuations and the corresponding entropy statistics found to oppose localization. This is the basis of a model of fracture according to which initially delocalized microcracks multiply without a correlation and their concentration can fluctuate so as to cause formation of clusters and merging into macrocracks becomes possible. As a result, there appear overstresses and the entropy-related condition for delocalization becomes violated. The cracking process is thus viewed as consisting of two stages, each with a characteristic time and the total time determining the life of a solid body under load. The author thanks S. N. Zhurkov and V. I. Vladimirov for interest and helpful comments. References 10: 9 Russian, 1 Western.  
[13-2415]

CLASS OF PROBLEMS IN NONLINEAR PROGRAMMING

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[Abstract] There is a class of problems in nonlinear programming which includes such a problem as optimum planning of a main production line along with an auxiliary preparatory one where the cost of the former depends on the volume of the latter. A problem in this class is formulated mathematically as one of finding two time functions  $x(t)$  and  $n(t)$  which will minimize the cost  $C(N, X, \tau)$  under given linear or nonlinear constraints on both  $0 \leq x(t) \leq b(t)$  and  $0 \leq n(t) \leq \alpha(X(t), t)$ , with function  $f(X) > 0$  and function  $T(X)$ , a rigorously descending function of  $X$  ( $\tau > 0$  a given quantity,  $X^* = X(\tau)$ ,  $X(t) = \int_0^t x(t') dt'$ ).

A plan is defined as a set of those two functions which satisfies the optimality criterion of minimum cost, replacement of  $n(t)$  by  $n'(t) = n_1(t) + n_2(t + \Delta t)$  is defined as a shift to the right, and a completely shifted plan is defined as one which does not admit any further shift to the right. Analogously definitions are given for a shift and a complete shift of  $x(t)$  to the left. A nonempty set of sequential plans is also considered, and the principle of minimum production time is applied for selection of the unique solution to the correctly formulated problem. With the aid of three lemmas and two corollaries, three theorems are proved pertaining to the sufficient and necessary conditions for existence of a solution. The author thanks V. Ya. Arsenin for interest and comments. Article was presented by Academician A. N. Tikhonov on 18 November 1982. References 2 Russian. [10-2415]



## QUANTITATIVE EXPRESSION FOR FUNCTION DESCRIBING TELEMETRIC SOIL MOISTURE READINGS

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[Abstract] A quantitative expression has been derived relating telemetrically obtained soil moisture readings to optical characteristics of the soil, specifically its spectral brightness. The dependence of the spectral brightness coefficient  $\alpha$  on the moisture content  $w$  is known to have three distinctly different ranges corresponding to different phase constitutions of the moisture. The low-moisture range extends from dry to maximally hygroscopic soil containing strongly bonded molecular and vaporous moisture, in this range  $\rho(w) = \rho_1 + \alpha(w_1 - w)^n = 0.26 + 0.01(4 - w)^{0.5}$ . The intermediate range is characterized by the highest sensitivity of the spectral brightness coefficient to changes in moisture level, in this range  $\rho(w) = \rho_2 + (\rho_1 - \rho_2)e^{-\alpha(w - w_1)} = 0.11 + 0.15e^{-0.24(w - 4)}$ . The high-moisture range up to saturation is characterized by capillary and free gravity moisture, in this range  $\rho(w) = \rho_2 + b(w - w_2) = 0.11 + 0.4(4 - 16)$ . A single relation covering all three ranges could not be obtained by either polynomial approximation or regression analysis and the method of least squares, but processing a large volume of experimental data has yielded  $\rho(w) = \rho_z + (\rho_0 - \rho_z)e^{-\alpha w^c} + dw^n$ . For achromatic argillaceous soils this relation is  $\rho = 0.09 + 0.19e^{-9.01w^{2.3}} + 0.001w^{0.9}$ . This universal relation facilitates calibration and extrapolation of soil moisture readings in 2-4% intervals with a relative error not exceeding 12%. The author thanks D. V. Chalikov for assistance in search for the optimum fitting expression. Figure 1, references 4: 3 Russian, 1 Western.  
[9-2415]

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